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13. ABSTRACT

The detection of a clock or clock-type mechanism in a piece of ordnance is a problem for the EOD man. This report describes an exploratory investigation to determine the spectrum produced by clock mechanisms. It describes the experimental setup, results, and conclusions drawn from the investigation. A filter is presented which appears to be capable of increasing the signal-to-noise ratio of the detected signal.

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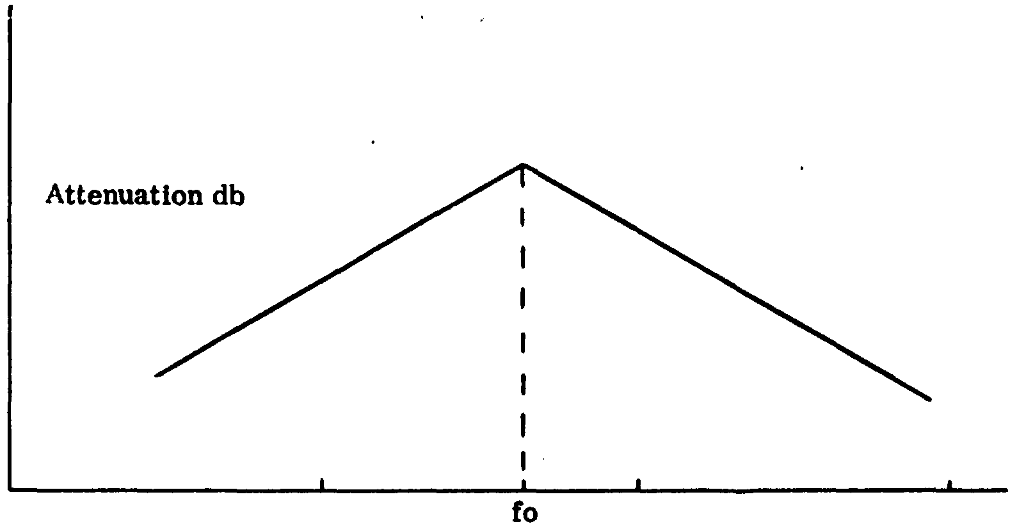

Figure 15. Attenuation Response.

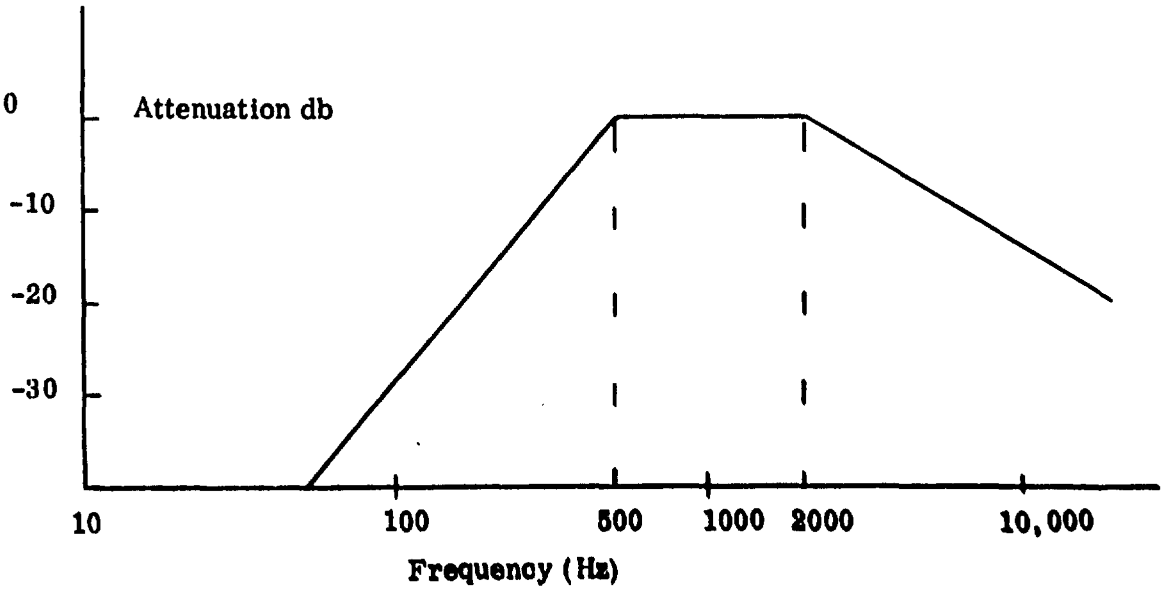

Figure 16. Filter Response.

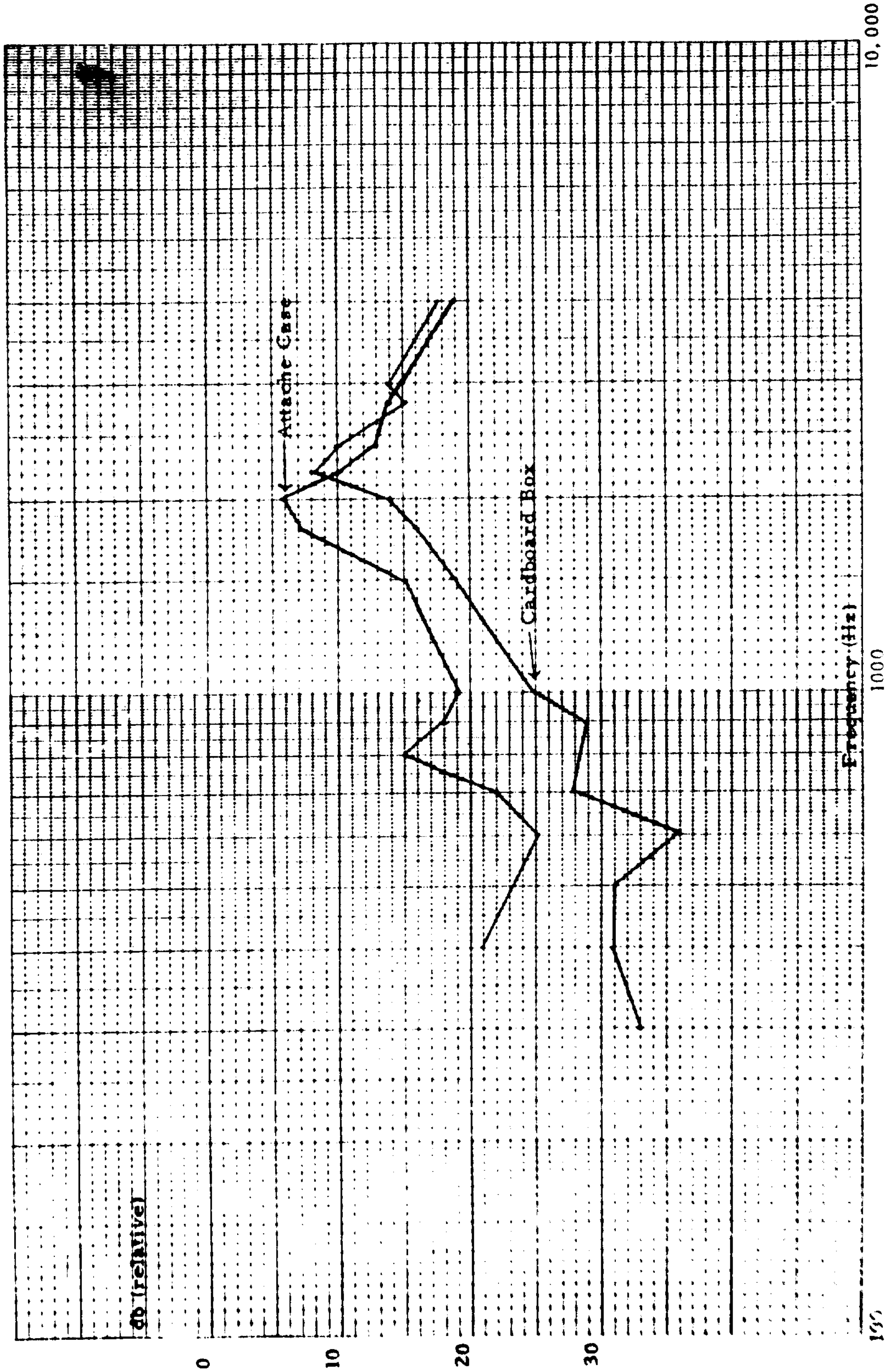

Figure 14. Attenuation Characteristics of Soft-Cased Packages.

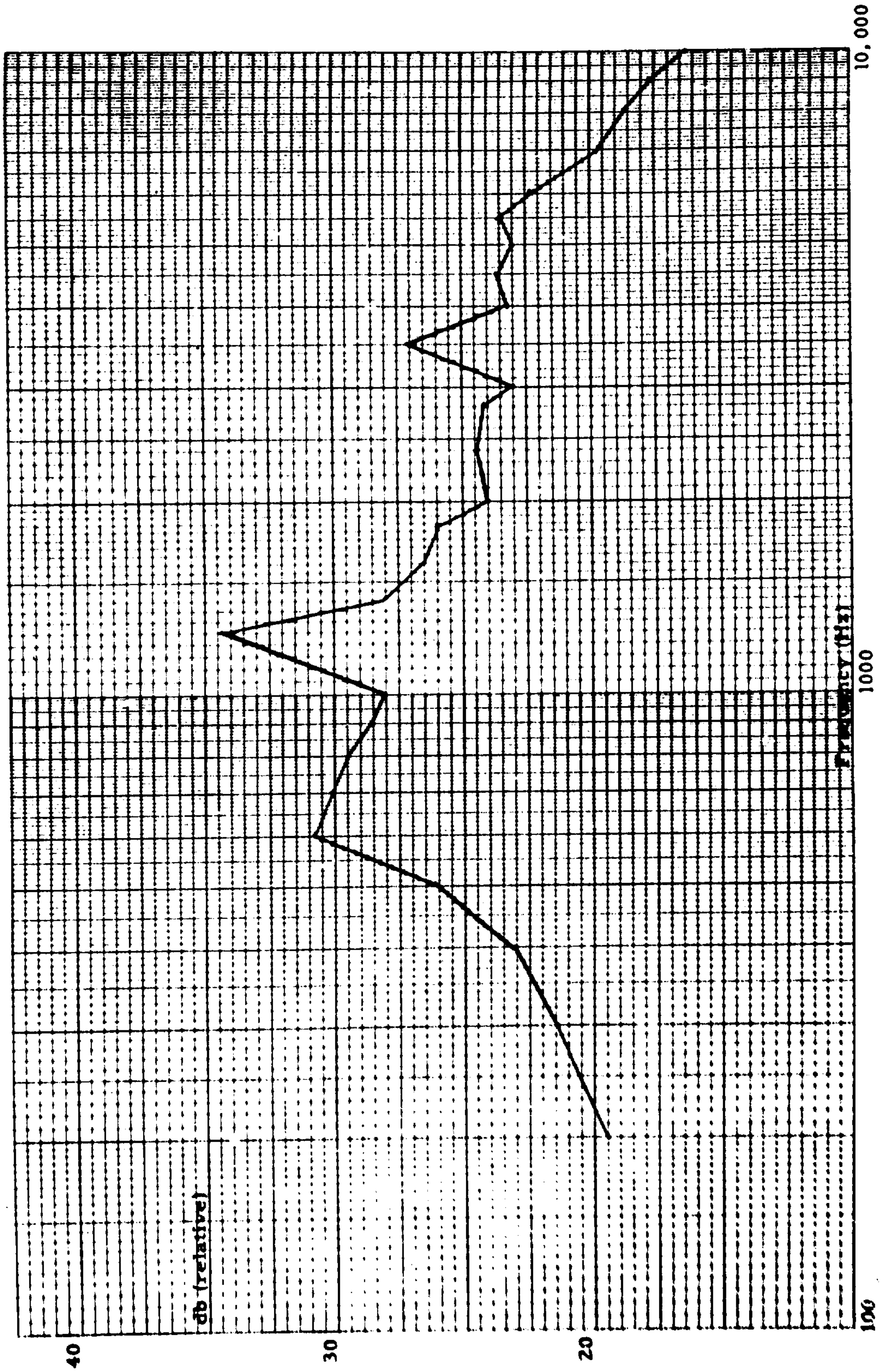

Figure 13. Total Average Signal Power Curve for Military Clock Mechanisms (Noise Corrected).

The average signal power curve corrected to eliminate the noise is shown in Figure 13. From this curve and a comparison between it and the average corrected wristwatch curve of Figure 8, it was noted that: (1) military clock fuzes have high signal power that tends to be as much as 10 to 15 db higher at certain frequencies than wristwatches, and (2) military clocked fuzes have large signal power distributed between 450 to 2,000 Hz.

The packages used to house the clocks were also investigated. It was noted that the military clock is normally housed in a metal container (bomb case). The signal power from the clock is not severely attenuated. In fact, resonant peaks were noted in some of the curves.

IED's are the types of devices in which wristwatches would be used as the timing device. Here packaging might be a steel container (pipe bomb), a cardboard box, or an attache case. The steel container response was much like that of the bomb case, very little attenuation with resonant peak at certain frequencies. The soft-cased packages (cardboard box and attache case) have an entirely different response. Figure 14 is an example of the attenuation due to these types of cases. This type of attenuation response can be characterized as shown in Figure 15 by a rising and then a falling response characteristically peaking at some frequency fo. For the packages analyzed, this peaking appears to be around 2,000 Hz.

From the previous discussion the following results are noted: (1) in a military package (steel container) the sound is easily picked up with very little attenuation, and (2) in soft-case packages the attenuation can be as much as 20 db with peaking response at approximately 2,000 Hz.

CONCLUSIONS

It would appear from the results indicated in this report that a matched filter technique should be used on future stethoscope designs to increase the signal-to-noise (S/N) ratio and thus increase the detection ability of the EOD man. This filter must attenuate the large noise experienced at the low frequencies. It must pass the frequencies in which significant signal power of both the military and wristwatch devices. This is in the range of frequencies between 500 and 2,000 Hz. It should also attenuate the frequencies above 2,000 Hz. Attenuation of these frequencies is necessary because of the loss of signal power and the possibility of experiencing man-made noise in this region. The attenuation of signal above 2,000 Hz should not be as great as that below 500 Hz since signal power may be experienced here.

An idealized filter response that meets these requirements is shown in Figure 16.

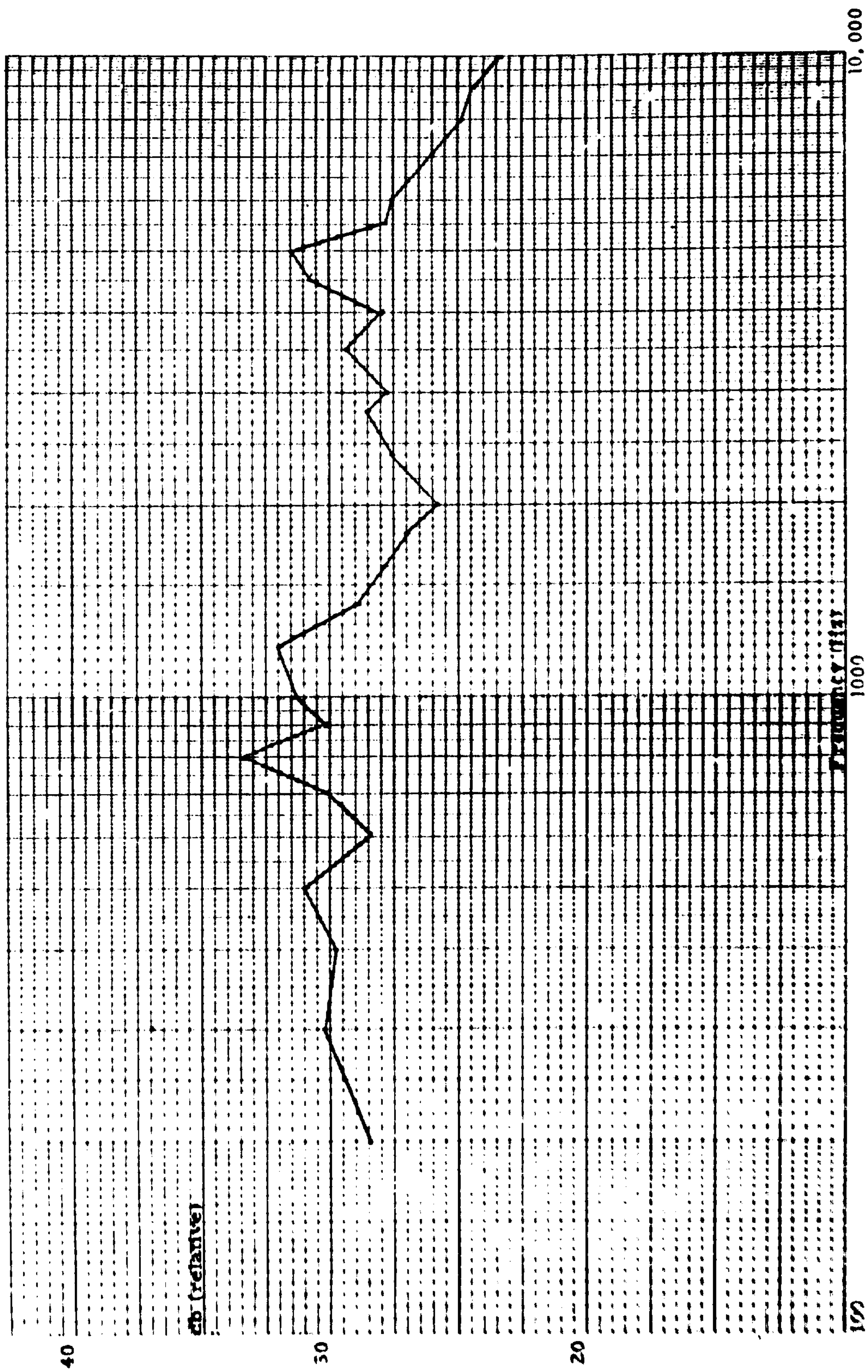

Figure 12. Average Signal Power Curve for the Mk 24 Clock Mechanism (Noise Corrected).

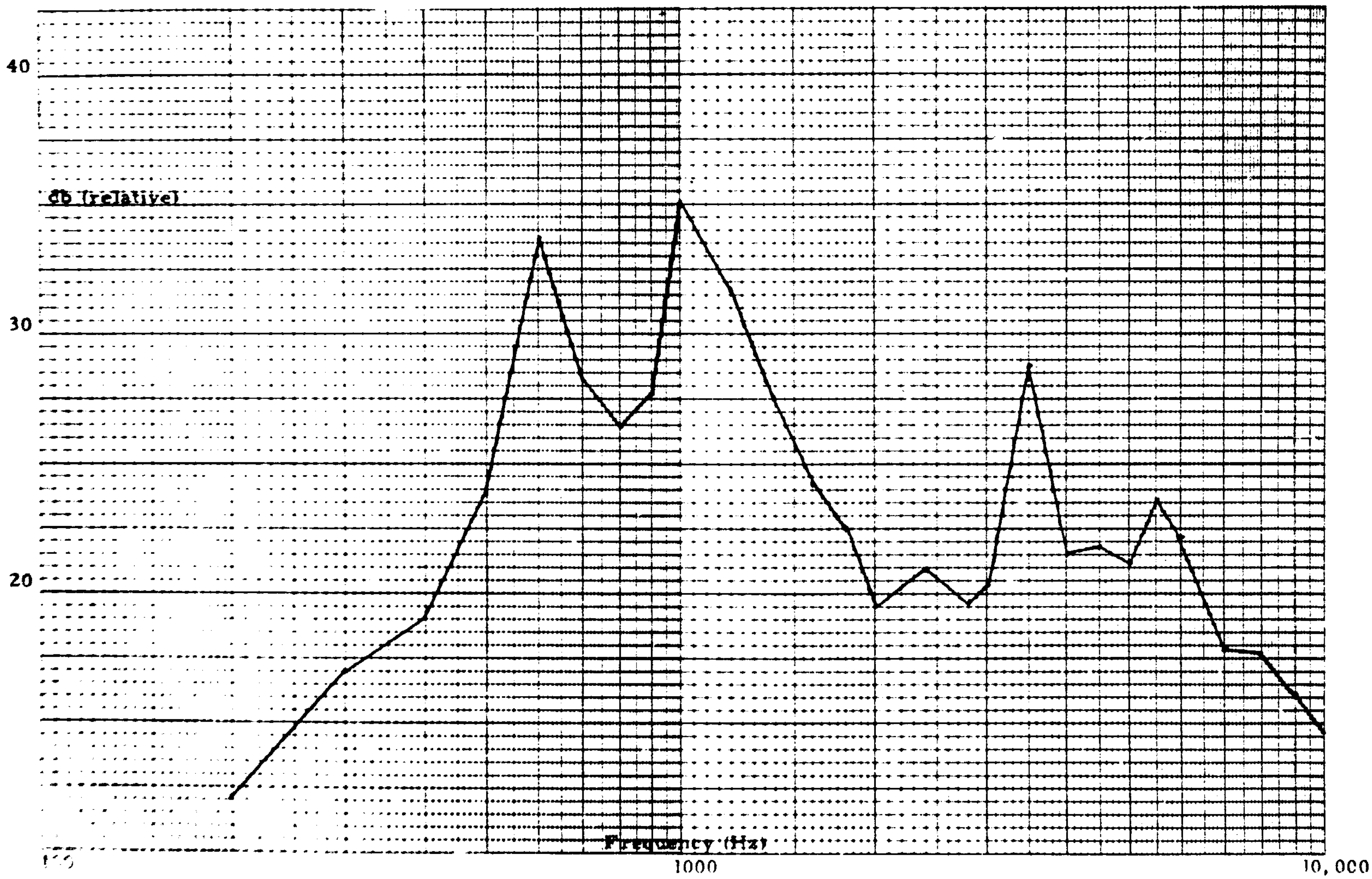

Figure 11. Average Signal Power Curve for CD 14 Clock Mechanism (Noise Corrected).

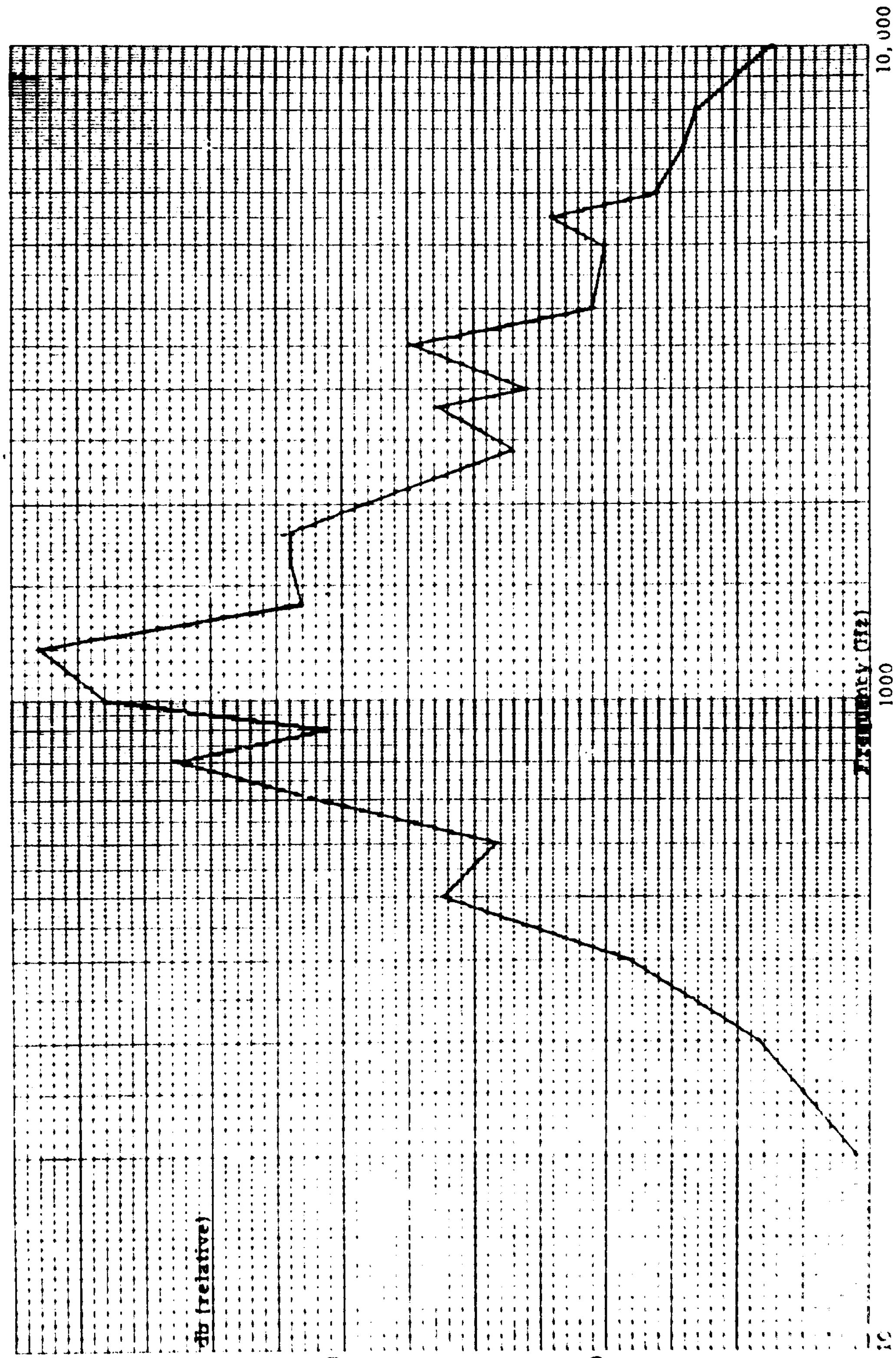

Figure 10. Average Signal Power Curve for CD 10 Clock Mechanism (Noise Corrected).

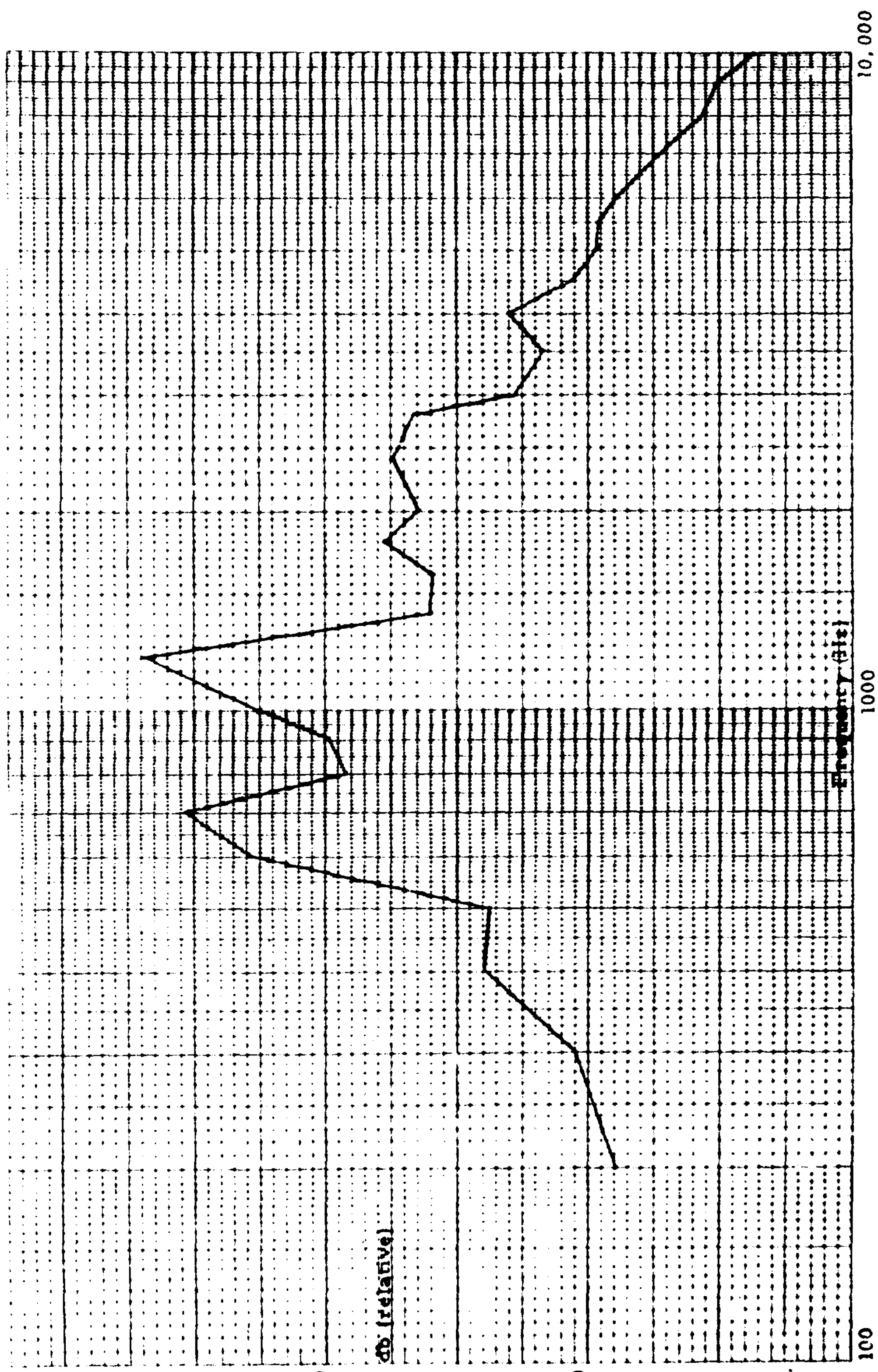

Figure 9. Average Signal Power Curve for Mk 8 Clock Mechanism (Noise Corrected).

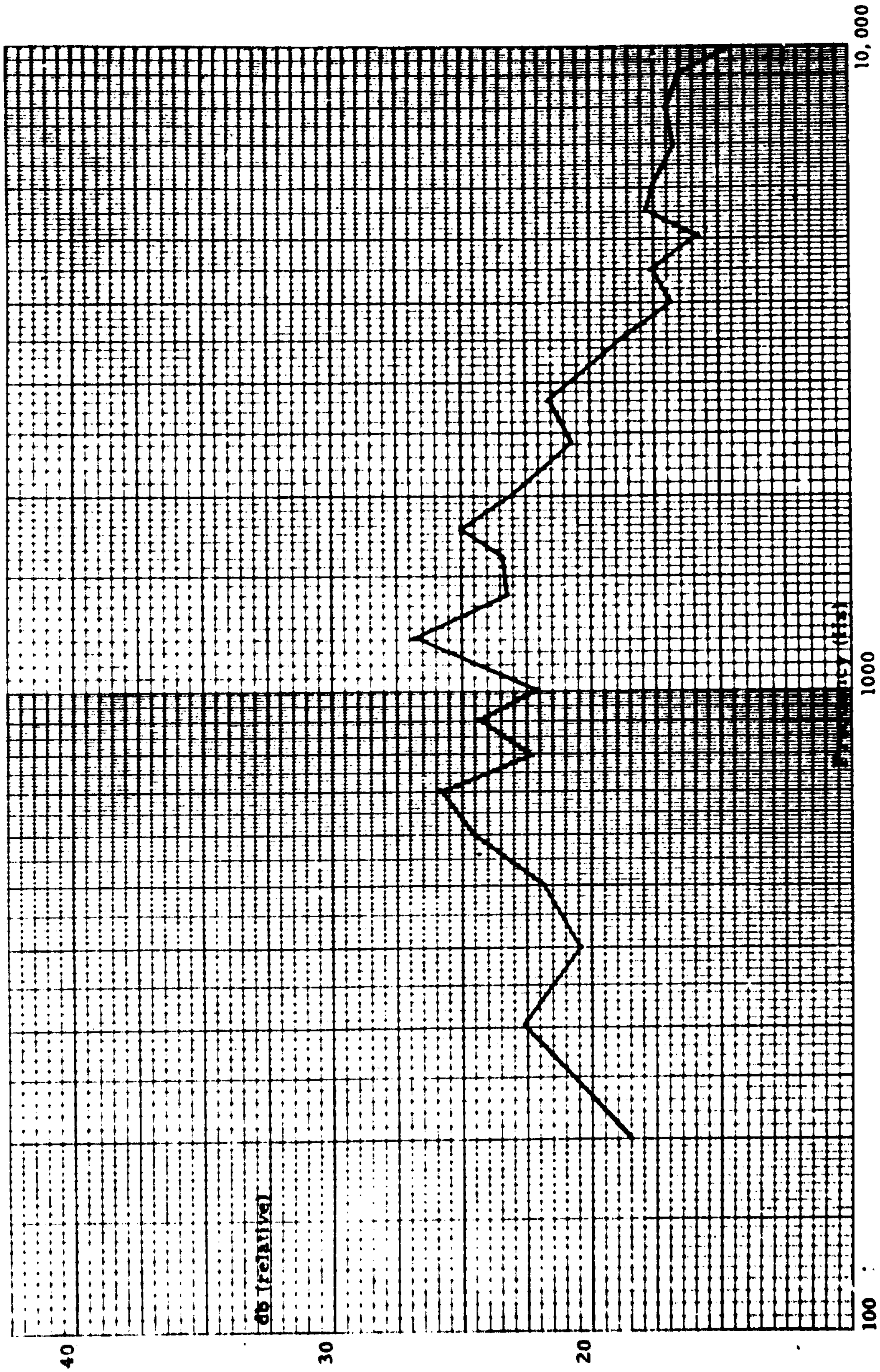

Figure 8. Average Curve for Wristwatches Corrected for Noise.

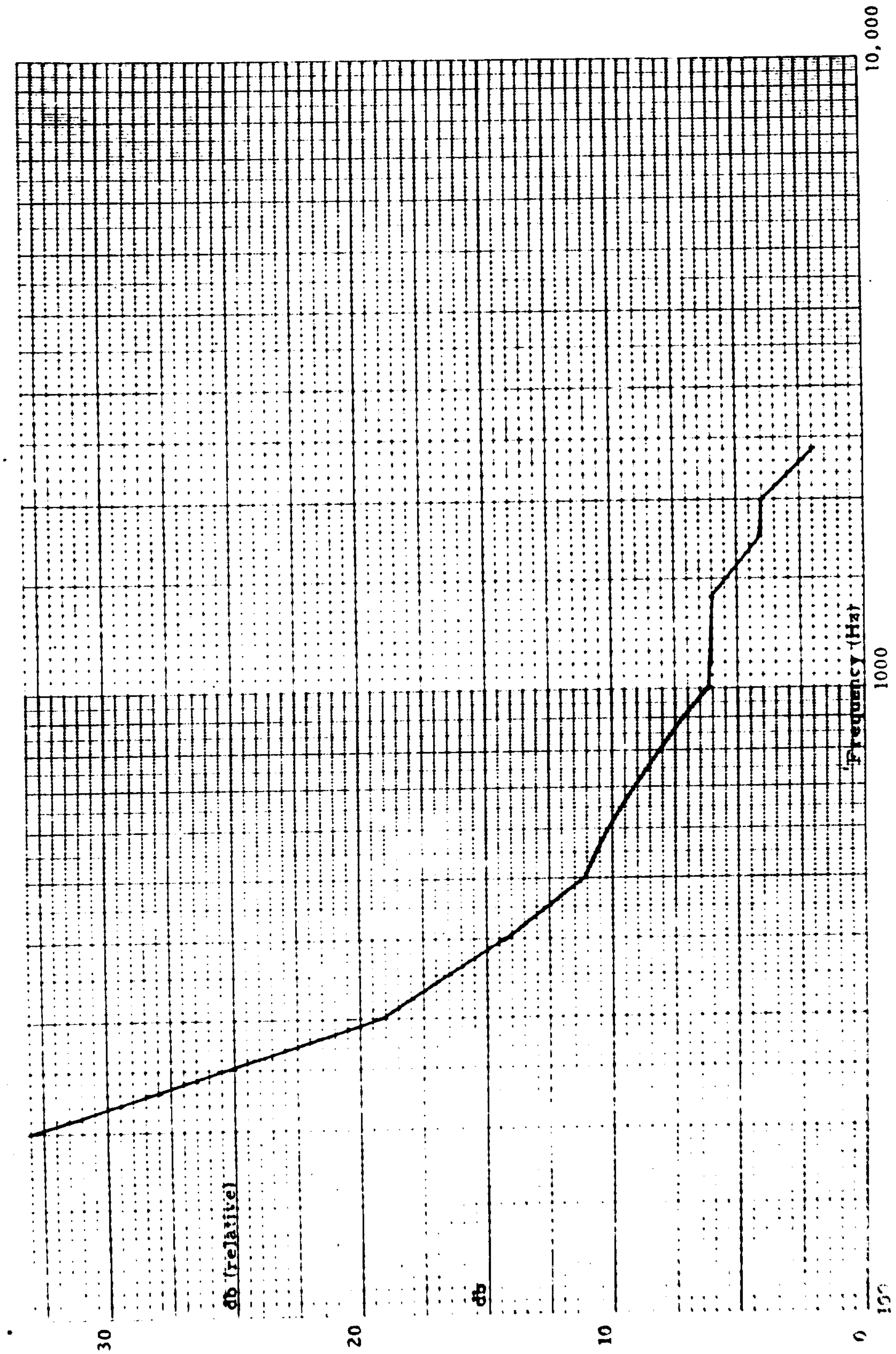

Figure 7. Typical Background Noise.

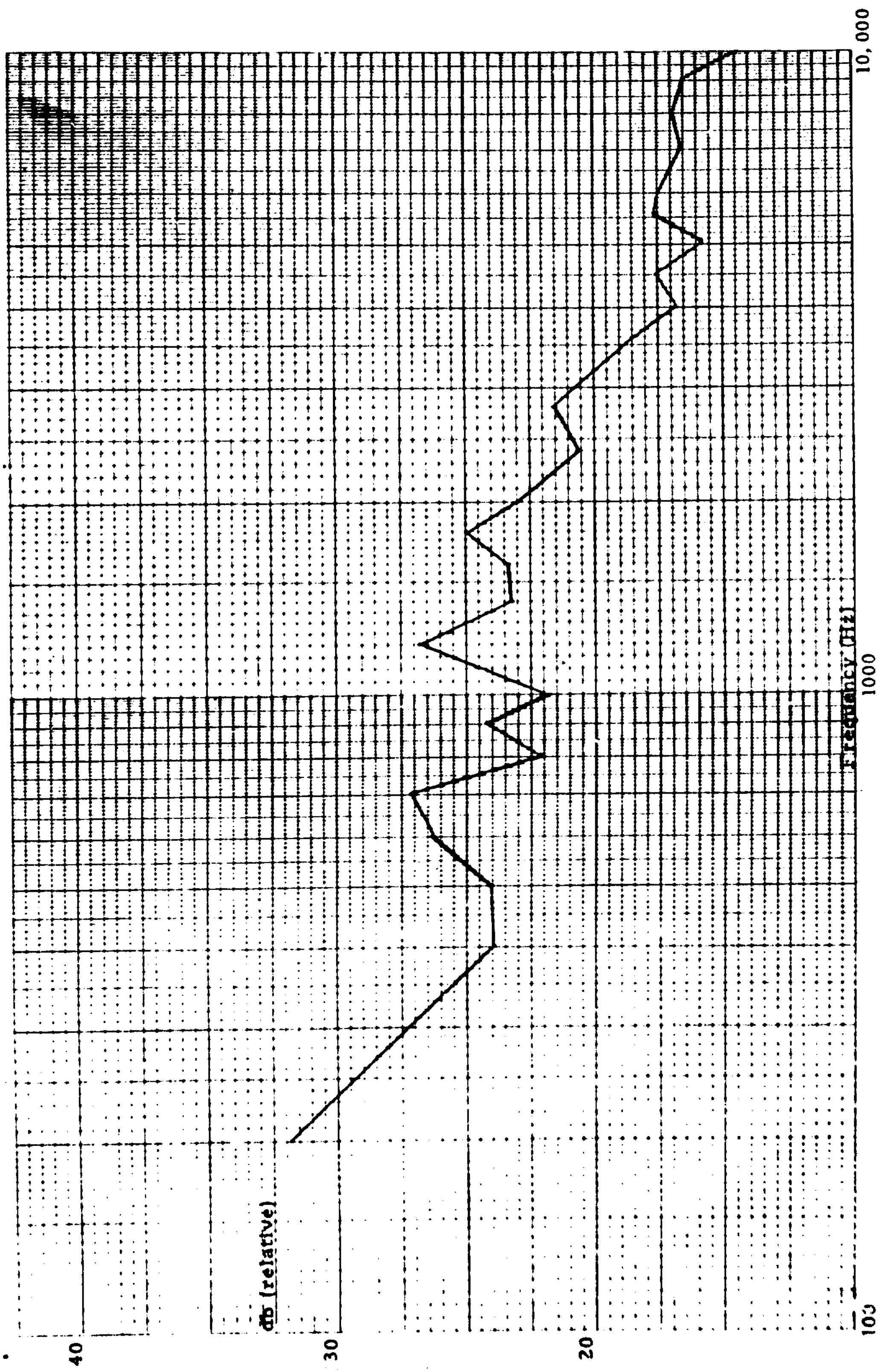

Figure 6. Average Curve for Wristwatches.

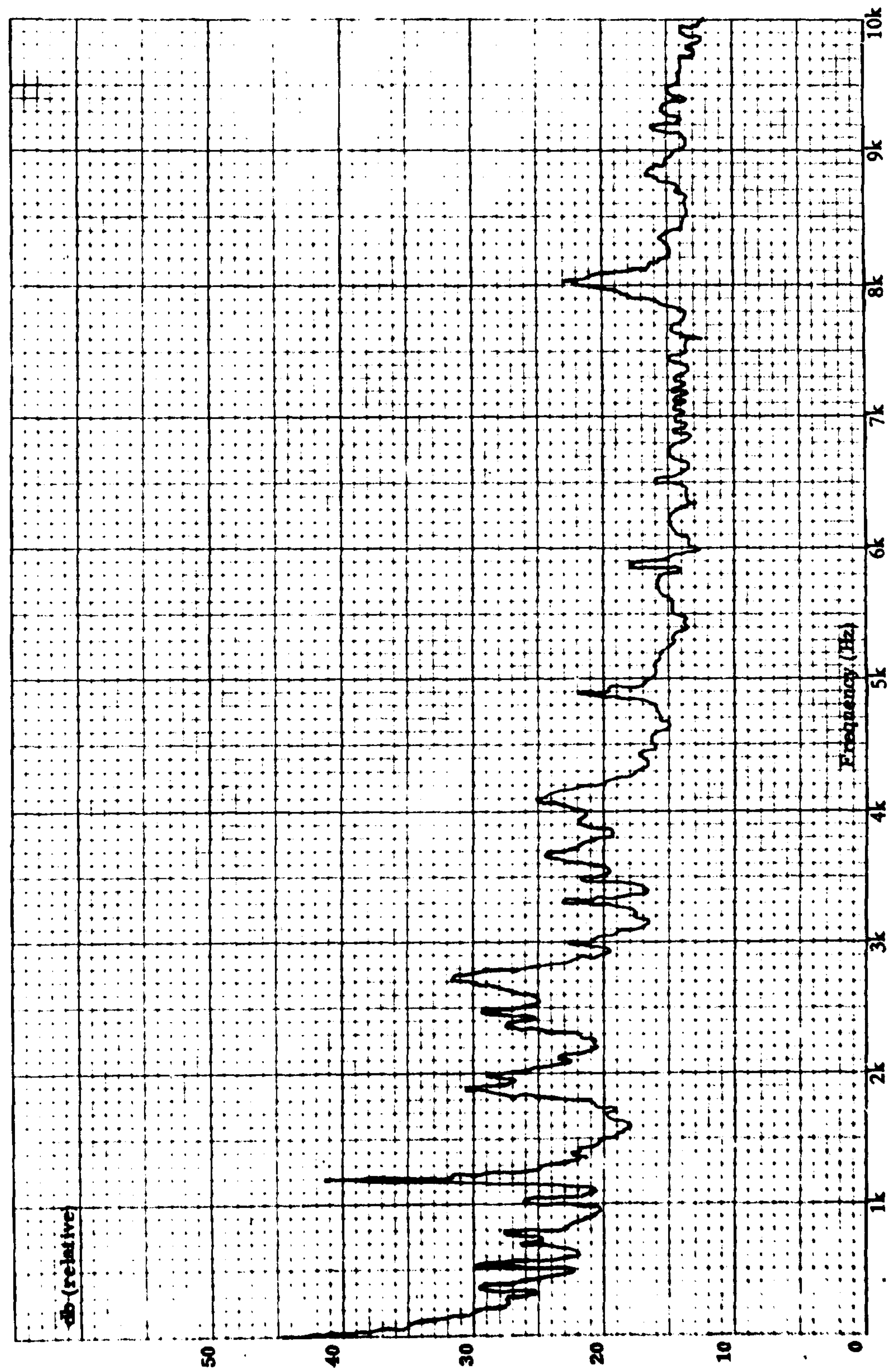

Figure 5. Example of Hard Copy Data Produced by the Analysis System.

The tapes were then sent to CBS Laboratories who analyzed them. The block diagram of the analysis system is shown in Figure 4. The analysis system consisted of an Ampex tape recorder connected to the input of the Spectral Dynamics Analyzer/Averager. Hard copy of the spectral data was displayed on an x-y recorder. The analyzer used was a Spectral Dynamics Model SD 301A real Time Analyzer and associated Model SD 302A Ensemble Averager.

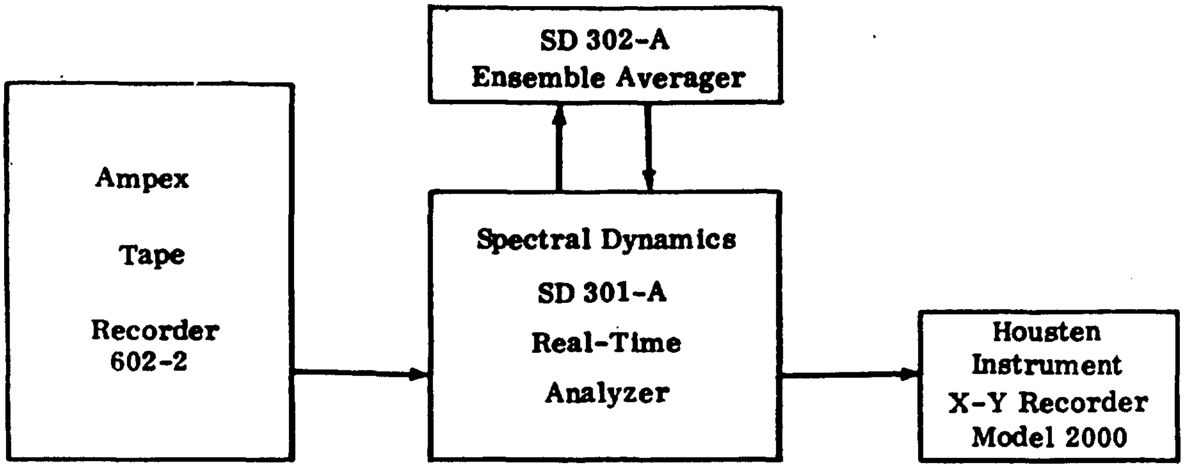

Figure 4. Analysis System.

Hard copy spectral data was then returned to the Naval Explosive Ordnance Disposal Facility (NAVEODFAC) where it was reduced. An example of the hard copy data is shown in Figure 5. Reduction consisted of averaging a number of similar clock sounds at particular frequencies. Frequency regions where large amounts of signal power is available could then be determined. Results of the data reduction are presented in the next section.

RESULTS

Two general types of devices were analyzed, wristwatches and military clock fuzes. Fourteen different wristwatches were analyzed and the data averaged in an attempt to distinguish the frequency region for this type of clock mechanism where the majority of the signal power exists. Figure 6 is the averaged curve for wristwatches. Background noise measurements were also made; a sample is shown in Figure 7. The average signal power curve was then corrected to show signal power less noise. This corrected curve is shown in Figure 8. From these curves it was noted that (1) most of the background noise is less than 600 Hz, and (2) most of the signal power from wristwatches is contained in the frequency band from 500 to 3,000 Hz.

Seventeen different military clocks were analyzed. These were divided into four groups. Noise-corrected curves of each of these are shown as follows:

Mechanism Group	No. Devices Analyzed	Figure
Mk 8	4	9
CD 10	2	10
CD 14	7	11
Mk 24	4	12

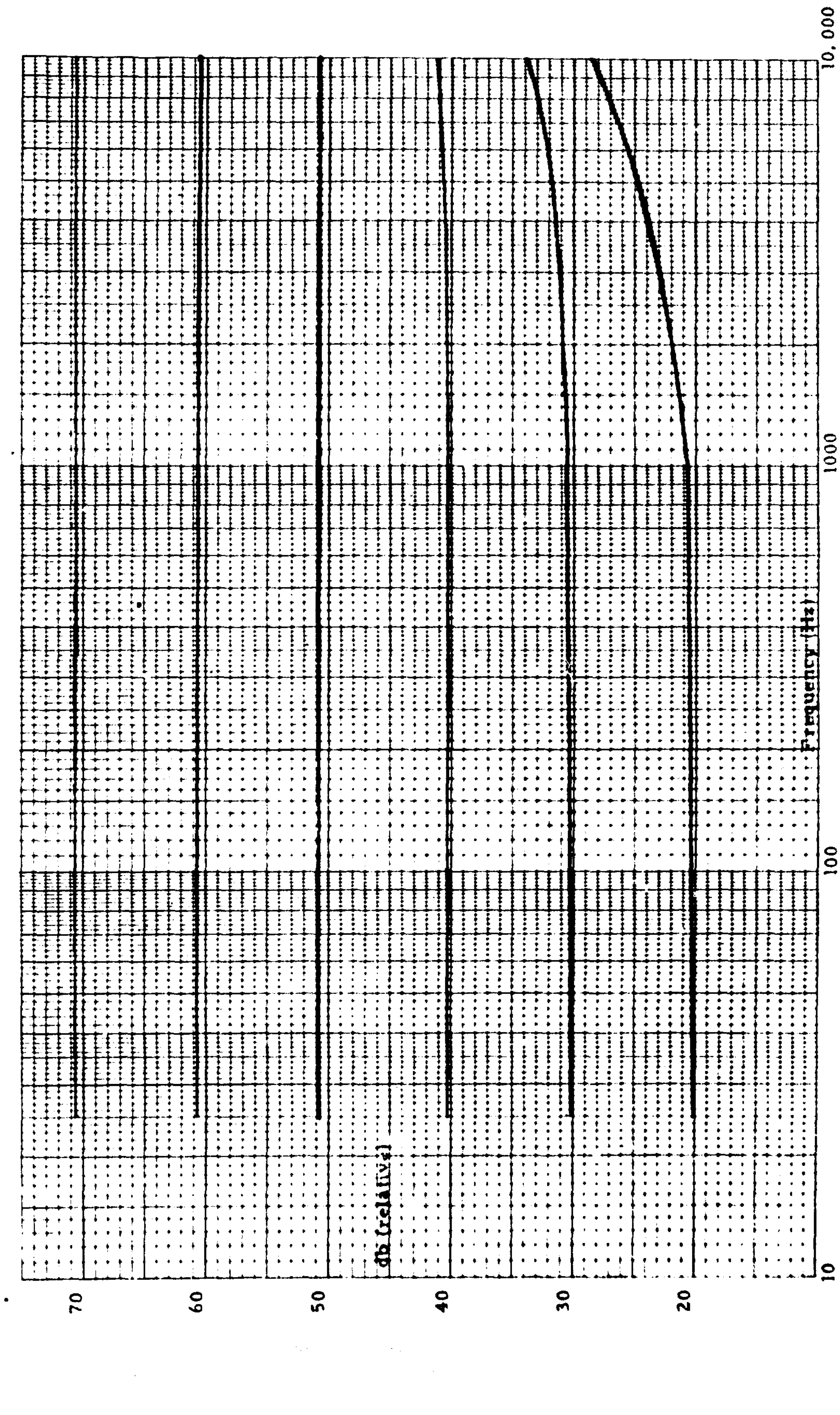

Figure 3. Amplifier Frequence Response.

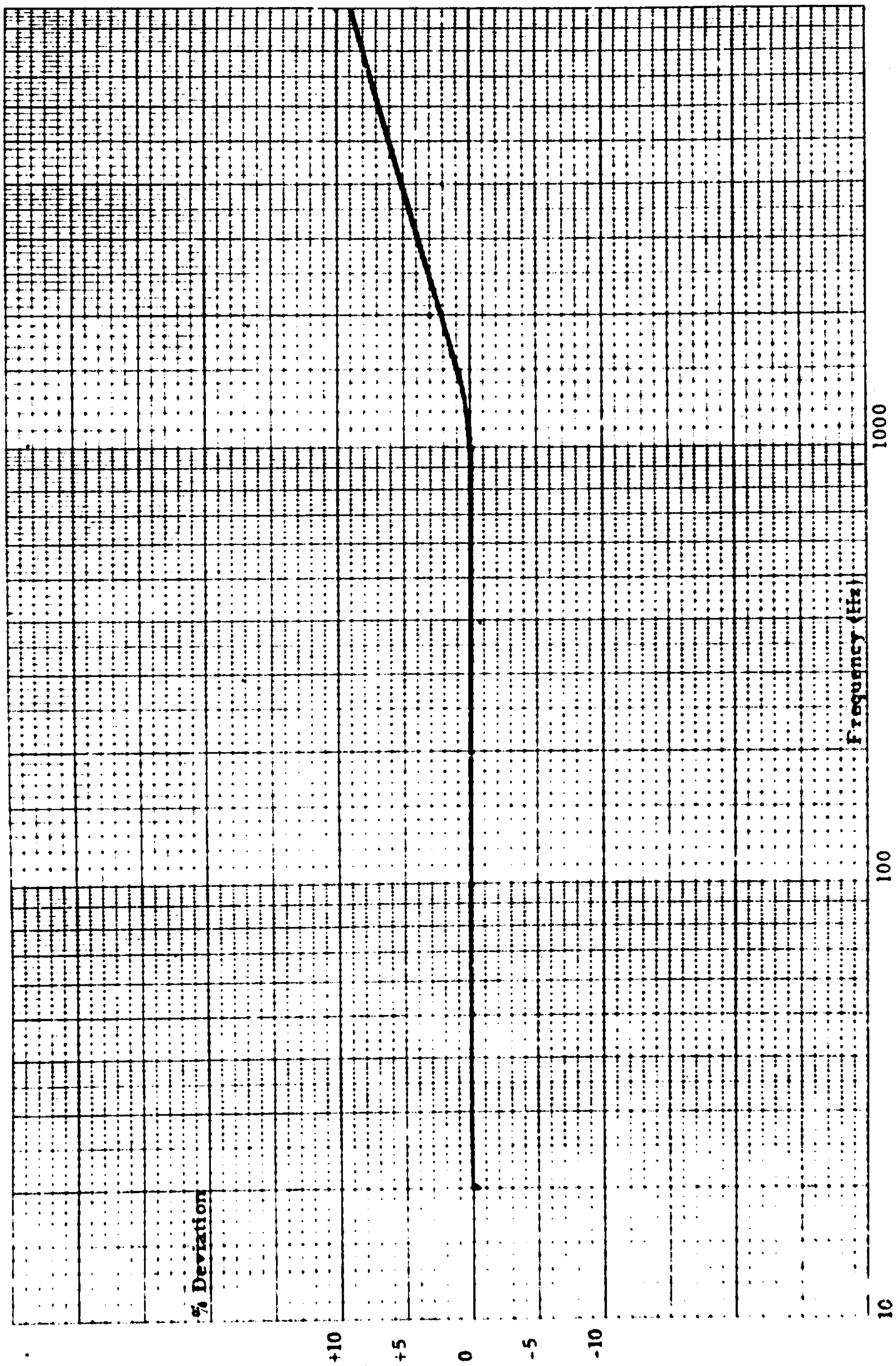

Figure 2. Transducer Voltage Frequency Response.

INTRODUCTION

The purpose of this report is to investigate the sound spectrum produced by clock mechanisms. This information is needed in order to design the signal processing filter to be incorporated in the explosive ordnance disposal (EOD) stethoscope.

This report details the experimental setup, results, and conclusions drawn from the investigation. A filter is presented which appears to be capable of increasing the signal-to-noise ratio of the detected signal. The effect of this will be to increase the ability of the EOD man to detect low-level clock signals such as those found in improvised explosive devices (IED's).

EXPERIMENTAL PROCEDURE

In order to investigate the sound spectrum produced by clock mechanisms, a large number of clocks, watches, and military time fuzes were analyzed. The initial step involved recording the clock sounds on magnetic tape. Figure 1 is a block diagram representation of the recording system. The device under test was one of the clock mechanisms. It was securely mounted to the transducer by electrical tape. The transducer was an Endevco Accelerometer, Model 2217E. This transducer has a voltage sensitivity of 89 mv/g with a 100 pf. A graph of voltage-frequency response with 100 pf external capacitance is shown in Figure 2.

The transducer was connected into the amplifier system. This system consisted of preamplifier (40 db gain, 1,000 mΩ input impedance) and a variable amplifier. The amplifier system gain and frequency response characteristics are shown in Figure 3. The amplifier gain was capable of being varied from 20 db to 70 db in 10 db steps. As can be seen in Figure 3, the frequency response is very flat for gains from 40 to 70 db. Some peaking was experienced with the 20 and 30 db gain settings at the higher (greater than 5,000 Hz) frequencies. This, however, was not of major concern since most of the measurements were made at gain settings greater than 40 db. The amplifier system was used to feed an Ampex full-track tape recorder, Model 351. This was used to record the clock mechanism sounds.

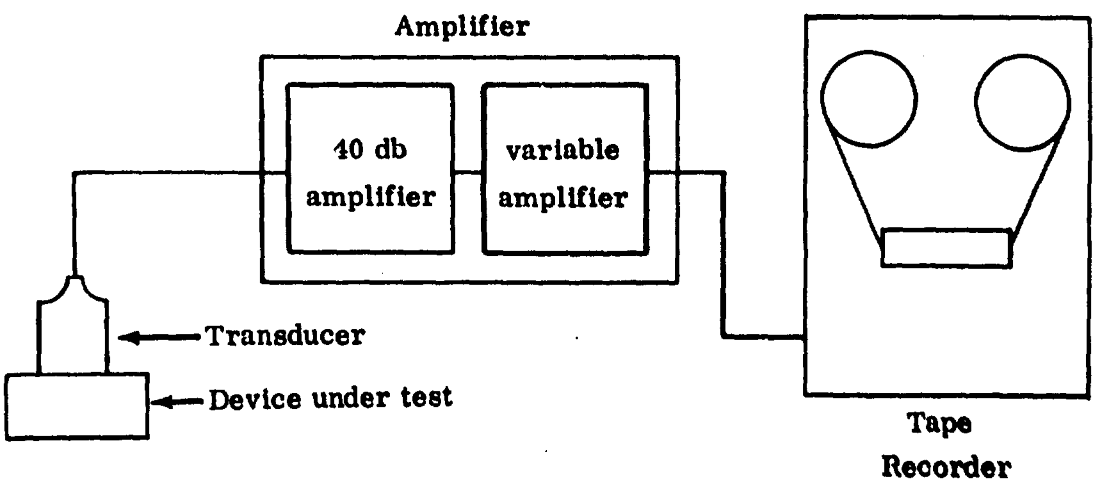

Figure 1. Recording System.

ABSTRACT

The detection of a clock or clock-type mechanism in a piece of ordnance is a problem for the EOD man. This report describes an exploratory investigation to determine the spectrum produced by clock mechanisms. It describes the experimental setup, results, and conclusions drawn from the investigation. A filter is presented which appears to be capable of increasing the signal-to-noise ratio of the detected signal.

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AN ANALYSIS OF CLOCK SOUNDS

By
John J. Pennella

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